We Claim

1. An apparatus for creating, utilizing a pair of oppositely opposed headphones, the sensation of a sound source being spatially distant from the area between said pair of headphones, said apparatus comprising:

(a) a series of audio inputs representing audio signals being projected from an idealized speaker located at a spatial location relative to an idealized listener;

(b) a first mixing matrix means interconnected to said audio inputs for outputting a predetermined combination of said audio inputs as intermediate output signals;

(c) a filter system for filtering said intermediate output signals and outputting filtered intermediate output signals; said filter system including separate filters for filtering the direct response and short time response and an approximation to the reverberent response; and

(d) a second mixing matrix means combining said filtered intermediate output signals to produce left and right channel stereo outputs.

2. An apparatus as claimed in claim 1 wherein said first mixing matrix means outputs a linear combination of said audio inputs.

3. An apparatus as claimed in claim 1 wherein said first matrix means applies a time varying gain to said audio inputs.

4. An apparatus as claimed in ~~any previous~~ claim 1 wherein said filters are independent of one another.

5. An apparatus as claimed in ~~any previous~~ claim 1 wherein said audio inputs comprise Dolby AC-3 inputs.

6. An apparatus as claimed in ~~any previous~~ claim 1 ~~to 4~~ wherein said audio inputs comprise stereo inputs.

7. An audio processing method for converting Dolby AC-3 inputs to stereo headphone outputs so as to substantially preserve the spatial components present in the inputs so as to create the appearance of sound located around a listener, said method comprising:

filtering each of the Dolby AC-3 inputs utilising first filters constructed to simulate the early part of the response from a suitably arranged virtual speaker to a corresponding listener's ear;

applying a second filter to each of said inputs to simulate the reverberant tail of a suitably arranged virtual speaker to a corresponding listener's ear; and

adding together the outputs from said filtering step and said applying step to produce left and right stereo headphone outputs.

8. A method as claimed in claim 7 wherein said inputs are summed before being input to said second filters.

9. A method as claimed in claim 7 wherein said first filters comprise short filter lengths whereas said second filters comprise substantially longer filter lengths.

10. A method as claimed in claim 9 wherein said first filters are about 2,000 taps in length and said second filters are about 32,000 taps in length.

11. An audio processing apparatus for converting Dolby AC-3 inputs to stereo headphone outputs so as to substantially preserve the spatial components present in the inputs so as to create the appearance of sound located around a listener, said apparatus comprising:

a first series of early response filters for filtering said inputs so as to produce outputs simulating the early part of the response from a suitably arranged virtual speaker to a corresponding listener's ear;

a second series of reverberant tail filters for filtering said inputs so as to produce outputs simulating the reverberant tail response from a suitably arranged virtual speaker to a corresponding listener's ear; and

a left and right output combining means for combining the outputs of said first and second series of filters so as to produce left and right headphone outputs.

12. An audio processing apparatus as claimed in claim 11 wherein the number of reverberant tail filters is two and said inputs are summed together before input to said reverberant tail filters.

13. A method of processing stereo input sound sources for playback over headphones so as to create the sensation of sound originating from around a headphone listener, said method comprising the steps of:

(a) producing sum and difference signals from said stereo input sound sources;

(b) applying a direct ear response and shadow ear response filter to said difference signal to form a filtered difference output;

(c) applying a direct ear response, a shadow ear response and a reverberant response filter to said sum signal to form a filtered sum output;

(d) forming a first headphone output from the addition of said filtered difference output and said filtered sum output; and

(e) forming a second headphone output from the subtraction of said filtered difference output and said filtered sum output.

14. A method as claimed in claim 13 wherein said responses simulate head related transfer functions for the placement of virtual speakers at substantially 30 degrees to the horizontal plane.

15. A method as claimed in claim 13 wherein said filters comprise forming the following outputs:

$$Sum' = \left(\sqrt{\left(1-\alpha^2\right)}(D+S)+\alpha R\right) \otimes Sum$$

$$Diff' = \left(\sqrt{\left(1-\alpha^2\right)}(D-S)\right) \otimes Diff$$

where:

Sum and Diff are the sum signal and difference signal respectively;

Sum' and Diff' are the filtered sum output and filtered difference output respectively;

D is the direct ear response - normalised to unity energy;

S is the shadowed ear response - scaled in proportion to D;

R is the reverberant response - normalised to unity energy;

α is the presence - the amount of reverberant feed in the mix.

16. A method as claimed in claim 13 wherein in said shadow ear response filter comprises a short FIR filter matching the frequency response and group delay of a signal derived from deconvolving a direct ear response from an appropriate shadowed response.

17. A method as claimed in claim 13 wherein said reverberant response filter approximates a delay line of between 5 - 10 ms

~~18.~~ A method of processing Dolby AC-3 input sound sources for playback over headphones so as to create the sensation of sound originating from around a headphone listener, said method comprising the steps of:

(a) producing sum and difference signals from the Right Rear and Left Rear input signals;

(b) producing an intermediate front left signal from the addition of the front left signal and the center right signal;

(c) producing an intermediate front right signal from the addition of the front right signal and the center signal;

(d) applying separate HRTF signals to said intermediate signals;

(e) applying an anti-phase HRTF to said sum and difference signals;

(f) summing the outputs of steps (d) and (e) to produce left and right channels headphone signals.

19. A method as claimed in claim 18 wherein said intermediate signals are delayed before the application of said HRTFs.

~~20.~~ An apparatus for creating, utilizing a pair of oppositely opposed headphones, the sensation of a sound source being spatially distant from the area between said pair of headphones, said apparatus comprising:

(a) a series of audio inputs representing audio signals being projected from an idealized sound source located at a spatial location relative to the idealised listener;

(b) a first mixing matrix means interconnected to said audio inputs and a series of feedback inputs for outputting a predetermined combination of said audio inputs as intermediate output signals;

(c) a filter system of filtering said intermediate output signals and outputting filtered intermediate output signals and said series of feedback inputs, said filter system including separate filters for filtering the direct response and short time response and an approximation to the reverberant response, in addition to feedback response filtering for producing said feedback inputs; and

(d) a second matrix mixing means combining said filtered intermediate output signals to produce left and right channel stereo outputs.

21. An apparatus as claimed in claim 20 wherein a predetermined number of said feedback inputs are also input to said second matrix mixing means.

22. An apparatus as claimed in any previous claim wherein said feedback response filtering comprises a reverberation filter.

23. An apparatus as claimed in claim 22 wherein said reverberation filter comprises one of a sparse tap FIR, a recursive algorithmic filter or a full convolution FIR filter.

a 24. An apparatus as claimed in ~~any of~~ claims 20 ~~to 23~~ wherein said audio inputs comprise a surround sound set of signals.

25. An apparatus as claimed in claim 24 wherein said feedback inputs are mixed with the frontal portions of said audio inputs only.

a 26. An apparatus as claimed in ~~any previous~~ claim 20 wherein said filter system includes a front sum filter filtering a summation of said audio inputs positioned in front of said idealized listener and said front sum filter

comprises substantially an approximation of the sum of a direct and shadowed head related transfer function for said front inputs.

27. An apparatus as claimed in ~~any previous~~ claim 20 ~~to 26~~ wherein said filter system includes a front difference filter filtering a difference of said audio inputs positioned in front of said idealized listener and said front difference filter comprises substantially an approximation of the difference of a direct and shadowed head related transfer function for said front inputs.

28. An apparatus as claimed in ~~any previous~~ claim ~~20 to~~ 27 wherein said filter system includes a rear sum filter filtering a summation of said audio inputs positioned in rear of said idealized listener and said rear sum filter comprises substantially an approximation of the sum of a direct and shadowed head related transfer function for said rear inputs.

29. An apparatus as claimed in ~~any previous~~ claim ~~20 to~~ 27 wherein said filter system includes a rear difference filter filtering a difference of said audio inputs positioned in rear of said idealized listener and said rear difference filter comprises substantially an approximation of the difference of a direct and shadowed head related transfer function for said rear inputs.

30. An apparatus as claimed in ~~any previous~~ claim 20 ~~to 27~~ wherein said filter system includes a reverberation filter interconnected to the sum of said audio inputs.

31. An apparatus for creating, utilizing a pair of oppositely opposed headphones, the sensation of a sound source being spatially distant from the area between said pair of headphones, said apparatus comprising:

a first series of filters for simulating the direct sound and early echoes;

a binaural reverberation processor for simulating the late reflections, said binaural reverberation processor further comprising:

at least one recursive filter structure and

a series of finite impulse response filters interconnected to said at least one recursive filter structure.

32. An apparatus as claimed in claim 31 wherein said binaural reverberation processor comprises at least two recursive filter structures each having a left and right channel finite impulse response filter interconnected to it output.

33. An apparatus as claimed in claim 2 wherein a first recursive filter structure has a longer reverberation decay time then a second recursive filter structure.

34. An apparatus as claimed in ~~any previous~~ claim 31 ~~to 33~~ wherein said binaural reverberation processor further comprises a series of recursive filter structures interconnected to sum and difference filters which in turn output to left and right channel outputs.

35. An apparatus as claimed in ~~any previous~~ claim 31 ~~to 34~~ wherein a portion of the output from one of said finite impulse response filters is fed back to the input of one of at least one of said recursive filter structures.

36. A method as claimed in ~~any of~~ claims ~~7 10 13 19~~ wherein said filtering is performed in utilising a skip protection processor unit located inside a CD-ROM player unit.

37. A method as claimed in ~~any of~~ claims ~~7 10 13 19~~ wherein said filtering is performed utilising a dedicated integrated circuit comprising a modified form of a digital to analog converter.

38. A method as claimed in ~~any of~~ claims 7 ~~10, 13 - 19~~ wherein said filtering is performed utilising a dedicated or programmable Digital Signal Processor.

39. A method as claimed in ~~any of~~ claims 7 ~~10, 13 - 19~~ wherein said filtering is performed on analog inputs by a DSP processor interconnected between an Analog to Digital Converter and a Digital to Analog Converter.

40. A method as claimed in ~~any of~~ claims 7 ~~10, 13 - 19~~ wherein said filtering is performed on stereo output signals on a separately detachable external device connected intermediate of a sound output signal generator and said headphones said sound output signals being output in a digital form for processing by said external device.

41. A method as claimed in ~~any of~~ claims 7 ~~10, 13 - 19~~ wherein said filtering is performed on stereo output signals on a separately detachable external device connected intermediate of a sound output signal generator and said headphones, said sound output signals being output in an analog form.

42. A method as claimed in ~~any previous~~ claim 36 ~~41~~ further comprising utilizing a variable zoom control to alter a perceived distance of the binaural room response.

43. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus is implemented utilising a skip protection processor unit located inside a CD-ROM player unit.

44. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus is implemented utilising a dedicated integrated circuit comprising a modified form of a digital to analog converter.

45. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus is implemented utilising a dedicated or programmable Digital Signal Processor.

46. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus operates on analog inputs by means of a DSP processor interconnected between an Analog to Digital Converter and a Digital to Analog Converter.

47. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus is implemented utilising a separately detachable external device connected intermediate of a sound output signal generator and said headphones said sound output signals being output in a digital form for processing by said external device.

48. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35~~ wherein said apparatus is implemented utilising a separately detachable external device connected intermediate of a sound output signal generator and said headphones, said sound output signals being output in an analog form.

49. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35, 43 - 48~~ wherein said apparatus further comprises a variable zoom control adapted to alter said filter coefficients in accordance with a control setting so as to alter a perceived distance of the binaural room response.

50. An apparatus as claimed in ~~any of~~ claims 1 ~~6, 11, 12, 20 - 30, 31 - 35, 43 - 49~~ wherein the reverberant part of the acoustic response is weighted toward the front of the listener.

51. An apparatus for creating, utilizing a pair of oppositely opposed headphones, the sensation of a sound source being spatially distant from the area between said pair of headphones, and furthermore providing an improved sense of the frontal sound sources being more solidly localised in front of the listener, utilising acoustic processing wherein the reverberant part of the acoustic response is weighted toward the front of the listener.